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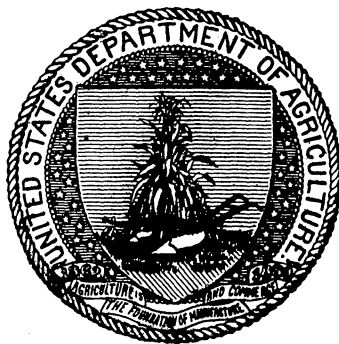
U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 226.

THE RELATION OF COYOTES TO STOCK
RAISING IN THE WEST.

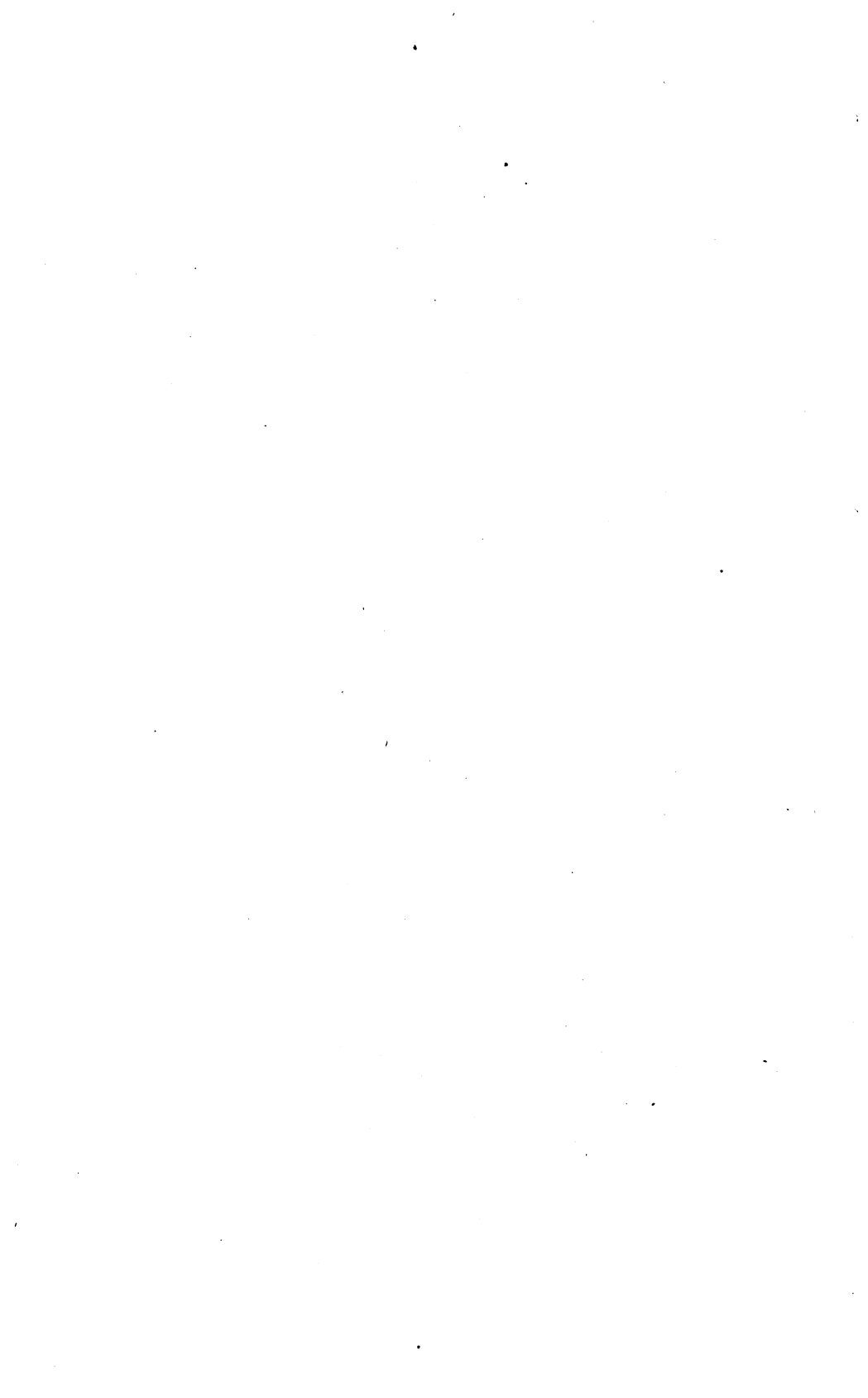
BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1905.



LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF BIOLOGICAL SURVEY,
Washington, D. C., May 20, 1905.

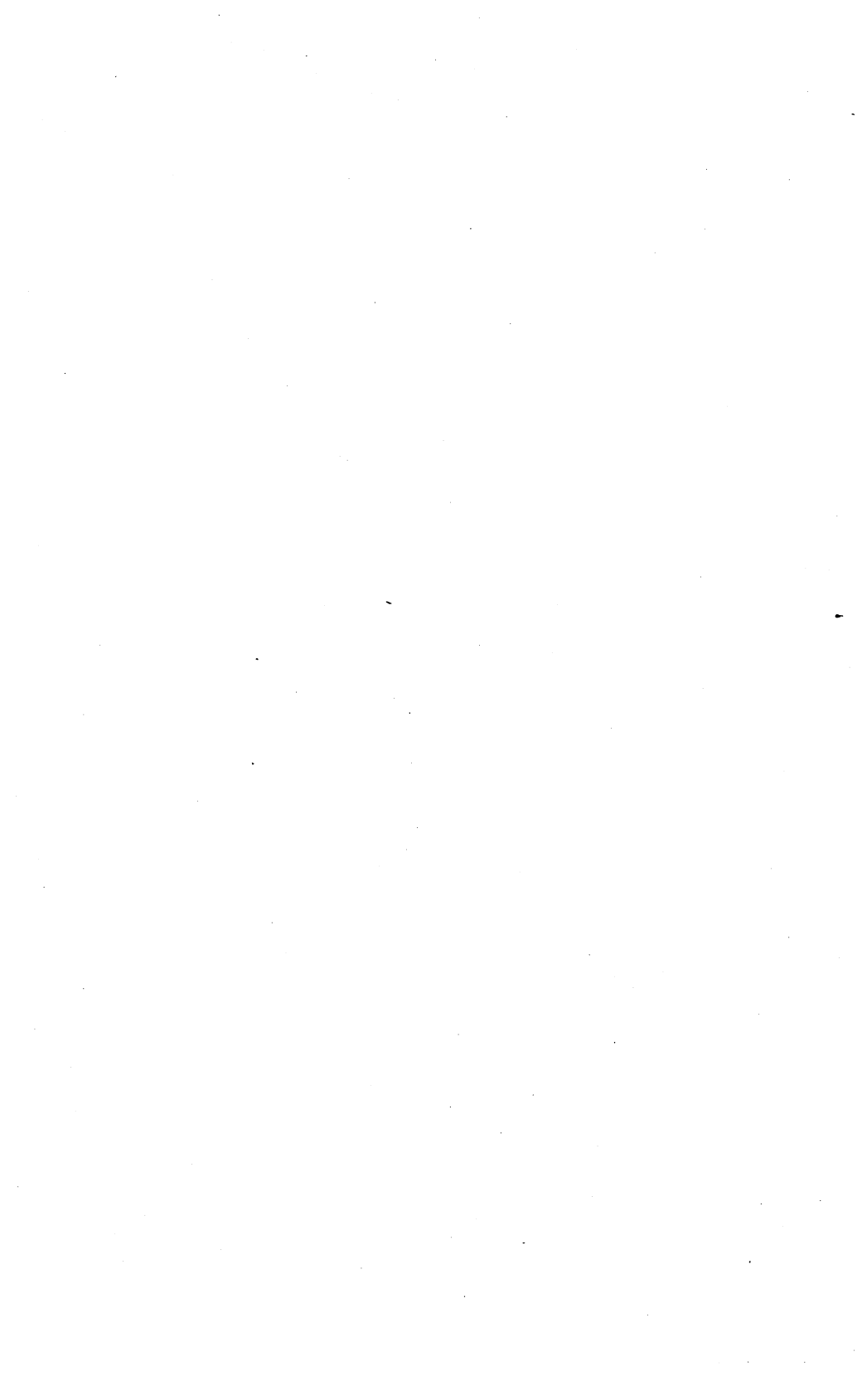
SIR: I have the honor to transmit herewith for publication in the series of Farmers' Bulletins a report on The Relation of Coyotes to Stock Raising in the West, prepared by David E. Lantz, assistant. The report contains the substance of a paper recently published as Bulletin No. 20 of the Biological Survey, but the matter is of such direct importance to the sheep industry that it seems desirable to give it the wider circulation of a Farmers' Bulletin. If, as seems probable from the evidence submitted, the sheep ranges of the West can be inclosed with coyote-proof fencing at moderate cost, the expensive method of herding may be done away with and the sustaining capacity of the lands thereby greatly increased.

Respectfully,

C. HART MERRIAM,
Chief, Division of Biological Survey.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE RELATION OF COYOTES TO STOCK RAISING IN THE WEST.

INTRODUCTION.

From early days until the present time the ranchmen of the Western States have suffered serious losses through the depredations of wild animals. Live stock of all kinds, more particularly sheep, are subject to the attacks of bears, panthers, and wolves, especially the small prairie wolves known as coyotes.^a These animals are generally distributed from the central Mississippi Valley to the Pacific coast, and from Costa Rica on the south to northern Athabasca on the north. In this vast range occur at least a dozen species, differing



FIG. 1.—Coyote.

from one another in size and habits. Few of them approach the gray or timber wolves in size, yet all are larger than the largest of the North American foxes. The larger species are the more injurious to live stock; the smaller feed more commonly on wild mammals and thus are less injurious, and sometimes positively beneficial, to agriculture.

^a "Coyote" is the Spanish name for these animals and serves to distinguish them from the larger gray or dusky wolves that occur in parts of the same range.

The present paper deals with the group as a whole and is confined to a discussion of the economic relations of coyotes in general to the stock interests of the West, and the best means of protection from their depredations.

The Biological Survey is engaged in an investigation of the food habits of all our birds and mammals, in the course of which the coyotes have been studied whenever possible. Some experiments have been made with a view to protecting stock from coyotes, from which it seems probable that fencing, proof against both dogs and wolves, may be erected at a moderate cost. Further tests will be made in the near future.^a

GENERAL HABITS OF COYOTES.

Coyotes are abundant in most parts of their range, except in the North and in thickly populated sections, where waste lands are scarce. Unlike the larger wolves, they seem not to have suffered through contact with the advancing tide of settlements in the West, so that in many sections they are now practically as numerous as in pioneer days.

The plains east of the Rocky Mountains and the higher plateaus of the Great Basin west of the mountains are especially adapted to the needs of the coyote. Cultivated areas are small; stock ranges are extensive; tall bunch grass, weeds, cactuses, and sagebrush afford good hiding places; the smaller native mammals are abundant, and when these natural resources of the country fail the introduced farm animals afford a plentiful supply of food.

In the State of Kansas warfare against coyotes has been long continued and has been stimulated in most of the counties by the moderate bounty of \$1 per animal killed. Statistics show that conditions have been reached where there is but little fluctuation from year to year in the total amount of bounty paid. At the present time nearly 20,000 coyote scalps per year are presented for bounty in the State. A dozen Western States have had similar experiences in dealing with the same pests without materially diminishing their numbers.

While in general denizens of the higher open plains, coyotes are found also on the low tropical coasts of Mexico and Texas and in the higher mountain ranges of the interior. In the northern and north-eastern parts of their range they inhabit partially wooded country, and even on the plains they are partial to broken and hilly sections.

^a Correspondence with persons interested in this subject is invited. It is hoped that farmers and ranchmen throughout the West who have had personal experience as to the efficiency of any form of fence as a protection against coyotes and other wild animals will write fully as to such experience. All such correspondence should be addressed to the Division of Biological Survey, U. S. Department of Agriculture, Washington, D. C.

Coyotes breed once a year. The mating season is late in January or early in February. The period of gestation is about sixty-three days. The young are produced in dens and number from four to eight or even more. The dens are usually enlarged from those made by badgers or smaller animals, and are often among rocks or in washed-out places along banks of streams. Probably at times they are made entirely by the coyotes. They are rarely far below the surface, but sometimes of considerable extent, and with two or more openings. Little attempt is made to provide nests for the young. In the Central West these are born early in April, and usually may be heard in the dens during May. In June they come out to play around the mouths of the burrows, which are finally deserted during July. By August 1 the young are left by the parents to shift for themselves.

In the earlier descriptions the prairie wolves were usually said to hunt in packs. Lewis and Clark, Say, Richardson, and others so reported, but the Prince of Wied met them only singly. It is probable that they hunt in numbers only when the quarry is large, as in the case of deer and antelope, and as many as three have been known to pursue a single jack rabbit.

FOOD OF COYOTES.

Coyotes feed chiefly upon animal matter, but when such food is scarce they freely eat peaches, apricots, grapes, and other fruits, and even melons, usually destroying more than they eat. In certain areas they feed largely on juniper berries, manzanita berries, and the fruit of the prickly pear. They eat also insects, though perhaps only occasionally.

The animal food ranges from the larger hoofed mammals to the smallest rodents, and includes also birds, reptiles, fish, and crustaceans. Horned toads and other lizards are eaten, and, on the low, tropical coast of eastern Mexico and Texas, coyotes have been seen searching the beach for crabs, fish, and turtle eggs.

BENEFICIAL FOOD HABITS.

Coyotes destroy many injurious species of mammals, and in this way are of positive benefit to farming interests. The various species of jack rabbit are often included in their diet, and the smaller rabbits are habitually eaten. The constant warfare of the coyote upon these rodents has much influence in keeping down their numbers, and the growing abundance of rabbits in some sections of the West has been attributed to the destruction of coyotes as the result of high bounties offered for them.

The various species of prairie dogs also are a staple coyote food.

The coyote usually captures them by hiding behind clumps of weeds or bunches of grass at some distance from the burrows, and when, in feeding, the unsuspecting rodent approaches near enough a few leaps enable the coyote to capture it. It is probably the fear of the coyote that causes the prairie dogs to crop off all the tall growing grass and weeds near their burrows.

In addition to rabbits and prairie dogs the food of the coyote includes rice rats, kangaroo rats, wood rats, ground squirrels, woodchucks, pocket gophers, chipmunks, and pocket mice. All of these are harmful to agriculture, and the coyote in preying upon them performs a valuable service to man. This service is not spasmodic, but lasts throughout the year and throughout the life of the coyote, and has an important influence in helping maintain the "balance of nature."

The coyote is useful also as a scavenger. In the prairie country, especially in winter, it comes into towns at night searching for garbage. Here it finds remnants of meat from the table, offal, and similar prizes. When hungry it rejects no animal food, not even carrion. The slaughterhouses near the towns are favorite feeding places, and the animals are often shot there. On the ranges they soon consume dead horses and cattle, leaving the bones clean.

INJURIOUS FOOD HABITS.

Considerable game is destroyed by coyotes, including quail, grouse, and wild ducks, and their eggs.

Formerly, when deer and antelope were abundant, they were frequently run down and captured by coyotes. To accomplish this the wolves hunt in packs of two or more, taking turns in chasing the victim selected. Their prey runs in wide circles, enabling the wolves to keep fresh until it is exhausted.

The coyote kills hens, ducks, geese, and turkeys. Its usual method of capturing them in daytime is to lurk behind weeds or bushes until the fowls are within reach. Turkeys, which range far afield in search of grasshoppers and other insects, are frequent victims. At night the coyote captures poultry from the roost unless care is taken to guard against its entrance. A correspondent of the Biological Survey wrote from Rexburg, Idaho, that one neighbor lost 60 chickens and another 30 in one night by coyotes. A correspondent in Mayer, Ariz., wrote that he had lost about a hundred chickens by coyotes, but that, although they destroyed poultry, he believed them to be beneficial, as they kept down the rabbit pest.

In approaching ranch buildings, either by day or by night, the coyote comes from the leeward side and with great caution; but once satisfied that no danger lurks in the shadows, it becomes very bold.

One has been known to make a dash into a dooryard, seize a chicken by the neck, and make off with it before anyone could interfere. In the same way the animal visits pig pens and takes young pigs from the sow.

Few of the mammals of the farm are exempt from the raids of coyotes. Even house cats roaming far from home in search of mice become victims. A correspondent of *Forest and Stream*, living in Wyoming, October 7, 1896, states that he had lost four cats in this way within a few months and that it seemed almost impossible to keep them in his neighborhood.

The coyote has been known to kill the young of most farm animals—colts, calves, pigs, lambs, and goats. Colts are seldom killed because the dams can usually protect them. Calves are taken only when the mother cow is feeding at a distance or has gone for water. The coyotes lie watching in the grass until this opportunity comes. Sometimes older animals are killed. Ranchmen in Oklahoma told the writer that in winter yearling cattle in good condition are sometimes killed by coyotes. To accomplish this two or more of them must hunt together, and get the victim separated from the herd.

THE COYOTE'S RELATION TO THE SHEEP INDUSTRY.

The coyote is especially notorious as an enemy of the sheep industry. In many parts of the West sheep raising has greatly languished because of the depredations of wild animals upon the flocks. While some of the injury is caused by the larger wolves, mountain lions, bears, and lynxes, the coyotes are by far the most formidable enemy. They are not only more abundant than the other animals mentioned, but they are present throughout the year, and their depredations are a steady drain upon the resources of the flock owner, comparable in extent to the losses caused by worthless dogs in many parts of the country.^a

A correspondent writing from Russell, Kans., in 1887, regarded the prairie wolf as the most troublesome of mammals. Its raids upon sheep and lambs were so frequent that flocks could not safely be left alone. Even when the herder was only temporarily out of view a wolf would make a dash into the flock and usually secure a lamb.

In 1888 a flock of some 4,000 sheep was driven through Bozeman, Mont., and night overtook them on the foothills south of that town. During the night coyotes entered the ranks and stampeded the sheep. Many ran over the bluffs, and in the morning sheep, dead and dying,

^a In 1891 the loss from dogs in Ohio was placed at \$152,034 and \$200,000 in Missouri. (Sheep Industry in the United States, U. S. Dept. of Agric., 1892.)

were several feet deep at the foot of the bluffs. Nearly 500 were counted in the pile, and for several days afterward sheep with lacerated ears and torn flanks wandered into barnyards in the vicinity.

In parts of the Southwest sheep growers have estimated their losses from wild animals to be 20 per cent of the flocks. The average loss reported from several States is 5 per cent. In nearly all the States the number of sheep has decreased during the past two years, and in the West one of the principal causes is losses from coyotes. At present the business of raising sheep flourishes best in sections where the flocks are under the care of herders. But this system of herding in large flocks results in constantly increasing deterioration of the pastures.

It is evident that the wealth of any State can be materially increased if it is possible everywhere to keep small flocks of sheep. Flocks increase rapidly under favorable conditions and good management, and the cost of keeping is small when herders can be dispensed with. The double product, wool and mutton, usually places the profit of handling sheep above that of cattle or horses. The gains also come oftener, since sheep mature in a year, while cattle and horses require three.

In the region about Seguin, Tex., according to Vernon Bailey, chief field naturalist of the Biological Survey, no sheep are kept, because of the abundance of coyotes. The region is occupied by small farms, mainly 80 to 500 acres, on which cotton, corn, sorghum, and vegetables are the principal crops. While there are few large stock ranches, each farm has abundant pasturage for horses and cattle and can support from 50 to 200 sheep on the surplus pasturage and the weeds that grow up on the farms. The farmers admit the advantage of introducing sheep, but the fear of coyotes deters them from the experiment.

Similar conditions prevail over large areas in many parts of the West. The number of sheep in the United States has been decreasing during the past two years, while the price of wool has been excellent and the demand for mutton steadily increasing. Montana, with an area of 146,000 square miles, leads the States in the number of sheep kept, which is 5,638,967.^a Yet England, with an area of only 50,867 square miles, has about five times as many as Montana. In Montana sheep are herded in immense flocks; in England every landowner and farmer keeps a small flock.

The advantage of sheep upon the farm as weed destroyers is not usually appreciated in America. The Iowa Agricultural Experiment Station reports that out of 600 species of grasses and weeds, cattle are known to eat only 50, horses 82, while sheep eat 550. With

^a Crop Reporter, U. S. Dept. Agric., February, 1905.

abundance of pasturage, favorable climate, good prices for wool and mutton, and increased fertility and productiveness of the soil upon which sheep are grazed, there should be a decided advance in the sheep industry. The chief discouragement seems to lie in the depredations of worthless dogs and coyotes.

The evil of worthless dogs can be best remedied by a resort to taxation. Dogs should be regarded as property and taxed sufficiently to put all of the dangerous and worthless curs out of existence.

DESTRUCTION OF COYOTES.

The coyote pest presents a serious problem, and various methods of dealing with it have been tried. None of them has been entirely satisfactory, and some have been decided failures. All of them combined have resulted in a partial check to the increase of coyotes in most parts of their range.

USE OF POISON.

Poison has probably killed the greatest number of adult animals, and in parts of Mexico has almost destroyed some of the species, but no such success has followed its use in the United States. Strychnine is the favorite poison, and is, all things considered, the only one suitable for the purpose.

In the use of strychnine, the dry crystals of strychnia sulphate are generally preferred, as the poison in this form is readily soluble. The poison is inserted with a knife in small chunks of meat or in the carcass of some animal left upon the prairie. The meat should be handled as little as possible, and if small pieces are used it is best to distribute it from horseback along trails used by the wolves. The animals are very cunning in detecting and avoiding poisoned meat, and some hunters are successful in allaying their suspicions by burying the bait.

It should be remembered that poisoned baits are as likely to attract dogs as wolves. When poison is to be used the entire neighborhood should be informed, and valuable dogs should be confined until the operations are over and all uneaten baits destroyed.

USE OF TRAPS.

Coyotes are not easily trapped. Some skill and a good knowledge of their habits are requisites for success. They travel in rather well-defined paths and usually hunt against the wind. Having a keen sense of smell, they easily detect the tracks of man, and if they have had previous experience of traps or guns they are suspicious of danger. In the wildest parts of the country remote from settlement

they are more readily trapped. The chances for successful trapping decrease with their familiarity with man, so that there is little probability that the process will ever have much effect on their numbers.

Field naturalists of the Biological Survey usually have experienced little difficulty in securing coyotes in traps. A No. 3 steel trap is generally used. A suitable place is selected along a narrow path or trail and the trap is sunk in the ground level with the surface and concealed with fine grass, leaves, or other material that will harmonize with the surroundings. At the same time care is taken that the material used shall leave the jaws of the trap free to spring clear of the covering.

The trap should be fastened to a bush or stake, or, if these are not available, to a clog. For the last a pole lying on the ground is best, since it may be utilized without moving it or disturbing the surroundings. If the trap is anchored to a bush or small tree the chain must be securely fastened with snap or wire. A stout stake over which the ring will not slip, driven out of sight into the ground, is better. Every part of the trap and chain is covered, and the ground left in as natural and undisturbed condition as possible.

Any kind of fresh meat will do for bait—rabbits and other small rodents are often used, but larger baits seem to be more attractive. It is also of advantage after setting the trap to make a “drag” of the bait for a quarter to a half mile, at the end of a rope from the saddle horn, and finally to fasten it to a bush or stake close to the trap, or cut it in bits and scatter all around the trap, so that not all can be reached by the coyote without walking over the trap. The skill of the trapper and the situation of the trap will determine the best arrangement. The suspicion of the coyote is lessened apparently after following the bloody trail of a well-planned drag.

Before setting the traps many trappers rub their feet and hands on a skin or some strong-smelling meat or carcass to conceal the human odor. Oil of anise or rhodium is sometimes used for the same purpose. Any strong odor is likely to attract the attention of the coyote and allay suspicion. Care must be taken not to spit on the ground or kneel or throw down any clothing in the vicinity of the trap. A good plan is to set a line of traps and leave them for a day or two, and then go the rounds with a horse and drag and bait the traps without dismounting.

HUNTING THE COYOTE.

Many ranchmen find dogs an efficient help in guarding against coyote depredations. For this purpose the small varieties are useless, since the coyotes do not fear them. Beagles and larger foxhounds are too slow. Staghoumds, Russian wolfhounds, greyhounds,

and their crosses are to be preferred; and at least three are needed to successfully chase and safely kill a coyote. These dogs soon learn to hunt wolves and are seldom known to harm sheep. Ranches on which they are kept are comparatively free from depredations of wild animals, while others but a few miles distant are by no means exempt.

Coyote hunts, in which an entire community engage, have become a popular feature of rural sport in some parts of the country. Such hunts have been held in Kansas, Colorado, Idaho, Oklahoma, and Texas. The method employed depends much upon the local topography and other conditions. Men on horseback, with greyhounds, engage in the sport when the country is open. The chase, as in coursing hares, is straight away, and when the quarry is overtaken the fight is won only by the overpowering numbers of the pursuers.

The writer was present at the second annual wolf hunt in the large Pasture Reserve, near Chattanooga, Okla., which took place November 24, 1904. The area covered by the drive was somewhat over 6 miles square. Over 700 people took part in the sport, either actively or as spectators, and while only 11 wolves were killed the hunters seemed to feel amply repaid for their efforts. Such hunts have the result of decreasing the number of coyotes and also afford a pleasant break in the monotony of frontier life. Their purpose, however, is not admitted to be that of sport, but to kill coyotes.

BOUNTIES.

Activity in the warfare against the coyote has been considerably stimulated by the payment of bounties from the public treasury of the States and counties. Nearly all the States in which coyotes occur have been for years maintaining such bounty systems. In some parts of the West these are supplemented by rewards from stock associations or ranch owners. The bounties from public funds have ranged from 25 cents to \$5 for each animal killed, but supplementary payments sometimes make them as high as \$15.

The subject of bounties in general has been already discussed by Dr. T. S. Palmer, of the Biological Survey.^a Doctor Palmer refers to the California coyote act of 1891, which was practically in force only eighteen months, but which cost the State \$187,485. As the bounty was \$5 per scalp, this represented the destruction of 37,493 coyotes. Kansas, with a county bounty of \$1 per animal, succeeds in destroying about 20,000 each year. In addition to the bounty, the pelt of an adult coyote is worth from 50 cents to \$1.50, according to its condition. However, most of the killing is accomplished in

^a Extermination of Noxious Animals by Bounties. Yearbook U. S. Dept. of Agr., 1896, pp. 55-68.

spring, when the female and her young are dug out of dens and the pelage of the adults is not in prime condition.

Doctor Palmer rightly concludes that in practice bounties for the destruction of noxious animals, paid from public funds, are usually objectionable. Probably those upon wolves and coyotes can be best defended. While it is certain that the encroachments of civilization, without the aid of such rewards, would have operated to diminish the numbers of the larger wolves, the observed effect of settlements on the coyote has been different, and bounties undoubtedly have been effective against them in certain parts of the country. Whether the results have been commensurate with the cost is another question. The chief objection to bounties is, after all, that they usually lead to fraudulent practices.

PROTECTION AGAINST COYOTES.

All the foregoing methods of destroying coyotes, even when combined, having failed to greatly decrease their numbers, it is necessary to consider means of preventing depredations upon live stock. If domestic animals can be protected, coyotes will be forced to return to the beneficial occupations of destroying noxious rodents and acting as scavengers.

FENCING AGAINST OTHER WILD ANIMALS.

Fencing as a means of protection against wild animals has for several years been in use in the Australian colonies and in South Africa. In Australia wire nettings are used successfully to keep rabbits, dingoes, and some species of kangaroos out of pastures and crops. In Cape Colony jackals are a great hindrance to sheep and ostrich farming, and the success attending the use of the nettings in Australia led to experiments with them in the South African colony. The results have been satisfactory. While the fencing is expensive, the advantages from its use have more than compensated for the outlay.

Mr. T. T. Hoole, president of the Upper Albany (Cape Colony) Farmers' Association, gives details^a of ten years' experience with jackal-proof fencing. He first imported netting 2½ feet wide, but found it insufficient after a few months. He added barbed wires to increase the height, but finally determined on 3-foot netting and four barbed wires as best adapted to his purpose, which is to inclose ostriches, cattle, springboks, and sheep. He has 18 miles of this kind of fencing, while a neighboring stockman has 45 miles built.

^a Agr. Jour. Cape of Good Hope, 1904, vol. 25, pp. 560-563.

The cost, including labor, of Mr. Hoole's fence when built of the best materials—sneezewood posts and kangaroo netting—was estimated at £106 (about \$500) per mile, but a fence intended for sheep alone could be built for less. Materials and labor are both much more expensive than in the United States and a fence similar to that described by Mr. Hoole could be built in most parts of the West for about \$200 to \$250 per mile.

Mr. Hoole names the following advantages of jackal-proof fences to sheep growers:

- (1) Decreased cost of herding.
- (2) Increased value of the wool, amounting to 3 cents a pound.
- (3) Increased number of lambs reared.
- (4) Increased value owing to early maturity and condition of the stock.
- (5) Less liability to contagion from scab.
- (6) Reduced death rate.
- (7) Additional security of the flock.
- (8) Improved condition of pasturage as against deterioration.

The last item alone he regards as more than repaying the entire cost of erection. Under the system of herding on the open veldt it becomes necessary to protect from wild animals by driving the sheep to a kraal for the night. In the vicinity of the kraal the ground is soon trodden bare, and deep parallel paths are worn in the surface. In a few years the torrential rains wash the paths into what are called "sluits"—similar to the "arroyos" of our own Southwest.

In the western part of the United States the practice of keeping sheep in vast herds has resulted in much deterioration of the ranges, due to overcrowding, and the cost of herding has absorbed much of the profits of sheep raising. The process of withdrawing lands for homesteads and the various reservations has diminished the free range and increased the crowding, until flock owners for their own protection have been compelled to purchase lands for range purposes. The day of free pasturage on public lands is fast passing, and with private ownership of ranges fencing must be resorted to to confine the flocks. The additional expenditure necessary to make the fences proof against coyotes would be inconsiderable when all the advantages are properly weighed.

INVESTIGATIONS CONCERNING COYOTE-PROOF FENCING.

If a coyote-proof fence of sufficient cheapness and durability to be practicable can be brought into general use for inclosing pastures, there is no reason why the sheep industry in the West should not be revived and greatly extended. If such a fence should at the same

time prove efficient against dogs, the benefit would extend to the whole country and result in an enormous increase of the productive resources of our farms. A coyote-proof fence would prove valuable, even if its use were restricted to corrals and small pastures for ewes during the lambing season.

The writer interviewed a number of farmers in Kansas who have had experience with poultry and farm animals in coyote-infested country. Several of them had for some years been using for corrals and small pastures woven-wire fences, and had found those from 57 to 60 inches high entirely coyote-proof. These fences have triangular meshes and are of sufficient weight to be suitable for all kinds of stock. Such fences, if set with the lower edge on the ground and anchored down where necessary, can safely be recommended as coyote-proof. Their cost, however, is possibly too great to bring them into general use for sheep pastures. Where land is valuable and pastures of the best, they will prove economical, for they have the merit of being both dog-proof and coyote-proof. Dogs, both large and small, that by chance get inside the inclosures are unable to get out, and have to be let out by the gate.

Between these rather expensive fences and the cheapest form that may be found efficient many grades may exist. In experiments to determine the efficiency of any form it is necessary to consider the familiarity of the animals with fences in general. In a new country a very simple fence at first might serve to keep out wolves, but ultimately would prove insufficient.

A writer in the *Nor'-West Farmer* states that when he first began sheep raising in Manitoba a two-strand barbed-wire fence was a complete barrier to the coyotes, but that in less than two years they became used to it and would go under or between the wires without hesitation. More strands were added without effect, until a woven-wire fence was adopted, which proved satisfactory.

In South Africa three types of fence have been in use for protection against jackals, and each has advocates among the farmers. The cheapest is built of strands of barbed wire placed close together and stayed at intervals by light strips of wood fastened to the wires by staples. In the second form the staying is done by light, smooth wire, woven in by machinery, involving more labor in the building. The third type is that recommended by Mr. Hoole. It is more expensive, but seems always to have stood the test of use. The others have not always been satisfactory, but their advocates claim that the fault has been in construction and not in design. The jackals have entered the inclosures through openings at the ground.

Mr. J. H. Clarke, of Laytonville, Mendocino County, Cal., for several years has succeeded in fencing coyotes from his sheep range.

In a letter to the Chief of the Biological Survey, dated March 4, 1905, he describes the fence and relates his experience:

The fence, inclosing nearly 4,000 acres, consists of redwood pickets 6 feet long driven into the ground 1 foot and leaving spaces or cracks not over 4 inches wide; posts 8 feet long and driven 2 feet, projecting 1 foot above the pickets; two barbed wires stapled to the posts 5 inches above the pickets and the same distance apart. These should be on the outside of the posts. The pickets are driven evenly by using a slat as a guide at the bottom and a line at the top. One barbed wire is placed at the bottom on the outside to prevent digging. The pickets are fastened to a No. 9 cable wire with a No. 13 wrapping wire. The posts are set 12 feet apart, or less, according to the surface, at top and bottom of each rise or indentation.

Where gulches or small streams are crossed boxes and gates are put in. Where larger streams are encountered a dam is first put in and the gate so swung as to rest on or against the dam head in the dry season.

The cost of construction varied from \$320 to \$400 per mile. Galvanized wire was used, and of the barbed the thickest-set four-pointed wire obtainable. If four-point wire could be had, with sharp points set not over 2 inches apart, the top wire might be dispensed with.

While this fence was begun in 1897, it was not finished until three years ago. It was partly experimental at first, and at the end of the second year only that portion of the range used for lambing was inclosed with a coyote-proof fence. We do not know that a coyote has ever scaled or jumped it. A very large coyote that got in through an accidentally "propped" floodgate, though chased by dogs all day, could not be made to jump out, even when cornered. Considering the steep, wild, and broken nature of the country, with several "slides" in the fence that could not be avoided when building, and which move and displace the fence during hard storms, it is not surprising that a few coyotes have gotten in. Fortunately, partition fences have aided in the capture of these before much damage was done. Two obstacles are encountered in keeping up this fence—trespassers, who cut or break a picket to get through, and slides.

Coyotes are very persistent, and when they see young lambs on the opposite side will follow the fence for miles, trying to find a hole. * * * None have gotten in this season.

When we began to fence against them, the coyotes were literally driving sheep out of the country. * * * Horses and cattle have taken their places, but return less than half the profit sheep did prior to the coyote's inroads. Excessive rains in winter and irregularity of landscape preclude the practicability of close herding. With us it was either abandon sheep or fence the pest out. Fortunately we adopted the latter.

While the fence used by Mr. Clarke is expensive, the complete success of his experiment is significant. In most parts of the West woven wire would be cheaper than pickets and would require less labor in its erection. Where the land is as uneven as that just described, the use of woven wire may be impracticable.

Mr. D. W. Hilderbrand, of California, who has built coyote fences for ranchmen in the San Joaquin Valley, recommends a 3-inch mesh woven wire fence 36 to 40 inches in height, with two barbed wires

above, $5\frac{1}{2}$ inches apart, and one at the bottom. He recommends that the posts be set 20 to 30 feet apart.

Under instruction from the Chief of the Biological Survey, the writer spent several weeks in the field during October and November, 1904, making such investigations as were possible during the limited time at his disposal. For the purpose of testing the ability of coyotes to pass over or through fences a unique experiment was made. The place selected was Chattanooga, Comanche County, Okla. South of the town lies the great Pasture Reserve, a large area practically without fences to interfere with the chasing of wolves. Coyotes were abundant and the cowboys skilled in their chase, so it was not difficult to procure the needed animals in an uninjured condition.

The experiment was made with all the forms of fence that could possibly be obtained or built with the limited resources of a new country. A long lane was first built, with sides 7 feet high, made with poultry netting of a small mesh. Fourteen cross fences of heights from 30 to 66 inches and of various designs were built at intervals along the lane. They were so arranged that the coyotes, introduced at one end of the lane, should have presented to them gradually increasing difficulty in passing the fences. Two coyotes were released singly into the lane, and their progress and methods of passing the cross fences were carefully noted.

The coyotes ran with their noses close to the ground and seemed to have no knowledge of jumping. Neither of them succeeded in getting over a fence more than 36 inches in height. The method was one of climbing rather than of jumping. All attempts to pass the obstructions began with efforts to get the muzzle through openings. If the entire head could be thrust through and the space was wide enough for the shoulders to pass, the whole wolf was able to follow. Both went through rectangular openings 5 by 12 inches and 5 by 8 inches, but the larger animal failed to pass a mesh 5 by 6 inches. The smaller animal went through an opening 4 by 12 inches and another 5 by 6 inches. Had these openings been triangular in form the animal could not have passed through.

In the experiments the animals, under excitement, were attempting to escape from confinement. In the judgment of the writer, the experiments are insufficient to determine what a coyote would do if the conditions were reversed and, impelled only by the stimulus of hunger, it were attempting to enter an inclosure built of these fences. The barriers would surely be far more formidable. Experiments with certain types of fence, inclosing sheep, in a country where wolves are numerous would be far more conclusive in establishing a safe basis for practical recommendations to farmers.

SUMMARY OF CONCLUSIONS REACHED.

The following conclusions are drawn from the experiments and from other data now available:

(1) Prairie coyotes will not willingly jump over a fence above 30 inches in height.

(2) They will readily climb over fences built of horizontal rails or crossbars, especially in order to escape from captivity.

(3) Barbed wires do not deter them from crawling through a fence to escape. Whether they will go through a closely built barbed-wire fence to attack sheep or poultry is still an open question.

(4) Woven-wire fences should have meshes, when rectangular, less than 6 by 6 inches to keep out coyotes. For such fences triangular meshes are much better than square ones.

(5) In fencing against coyotes with woven fences care must be used to see that there are no openings at the ground through which the animals can force themselves, since they are more likely to crawl under a fence than to jump over it.

(6) It seems reasonably certain that a fence constructed of woven wire with a triangular mesh not over 6 inches across and having a height of 28 to 42 inches, supplemented by two or three tightly stretched barbed wires, would prove to be coyote-proof. It is difficult to make exact estimates of the cost. Woven fences differ in weight, price, and durability, and freight charges on materials depend on the distance from distributing points. The cost of posts and labor varies much. An estimate based on so many variable factors is of little value, but an average of \$200 per mile would probably allow the use of the best materials.

Further experiments with wire fences will be made by the Biological Survey in cooperation with sheep growers in the West, and the results will be given to the public as early as practicable.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.:

No. 16. Leguminous Plants. No. 22. The Feeding of Farm Animals. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds: And How to Kill Them. No. 29. Souring and Other Changes in Milk. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Culture and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 54. Some Common Birds. No. 55. The Dairy Herd. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. Insect Enemies of the Grape. No. 71. Essentials in Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. 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